Shell Questacon Science Circus

Professional Development workshop

Climate, Global and Human Change

The Science Behind the Issues

Australian Government
Department of Education, Science and Training

THE AUSTRALIAN NATIONAL UNIVERSITY

Climate, Global and Human Change has been developed under an ecologically responsible framework. After all, it would be inconsistent with the concepts in this workshop, if the workshop itself generated large amounts of greenhouse gas emissions during development and delivery.

The environmentally friendly strategies employed include the following:

Air and vehicle travel will be offset using greenhouse gas emission abatement programmes.

The greenhouse gases generated from the paper used in this booklet will be offset using abatement programmes.

Every endeavour has been made to use activity materials that have recyclable packaging.

This booklet has been printed on recycled paper.

As much as possible, the materials used to demonstrate the activities in the workshop today have been acquired second hand or were already in Questacon's stores, reducing the amount of new materials that were purchased.

Produced and published by Questacon – The National Science and Technology Centre, King Edward Terrace, Canberra, ACT. 2600. Australia.

All illustrations by Mike McRae, contact: cthnonicdreams@hotmail.com

Contents

What is the greenhouse effect?

Climate change concepts:

- The greenhouse effect is natural and due to heat-trapping gases in the atmosphere.
- The greenhouse effect has been enhanced by human activity like burning fossil fuels, tree clearing and farming cows and sheep.

What you'll need

- A glass jar
- Strong lamp (120 watt) or a sunny spot
- 2 thermometers

Time required: 30 min

What to do

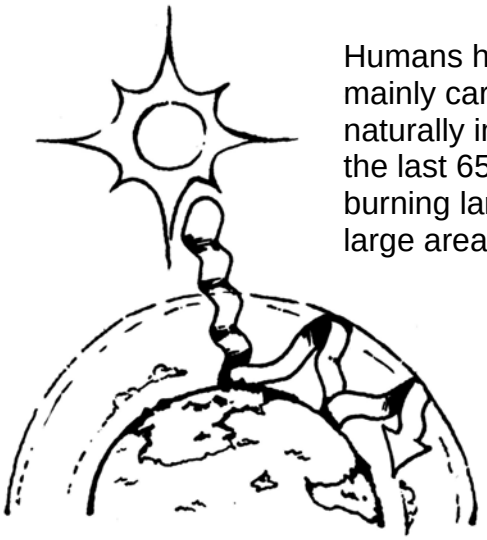
1. Place two thermometers in front of the lamp or in the sun and record the temperatures of both.
2. After a few minutes cover one thermometer with a glass jar (you may need to stand the thermometer up).
3. Record the temperatures of both thermometers every minute for at least 10 min.

What's happening in this activity?

The heat energy from the lamp or sun passes through the glass and some of this energy is trapped inside. This warms the air inside which is unable to mix with the cooler air outside the jar. The glass simulates the layer of greenhouse gases in the atmosphere that trap heat energy.

What's happening across the planet?

Greenhouse gases trap heat from the sun in our atmosphere. This is a natural process keeping the average global temperature at around 16°C. Without the natural greenhouse effect the average temperature across the planet would be -17°C, meaning the world would be covered in ice!



Humans have been producing large amounts of several greenhouse gases: mainly carbon dioxide (CO_2), methane and nitrous oxide. These occur naturally in the atmosphere, but are now at levels higher than any time in the last 650 000 years. The increase in greenhouse gases is caused by burning large amounts of fossil fuels for industry and transport. Clearing large areas of forest has also contributed to the increase.

The unnaturally high concentration of greenhouse gases currently in the atmosphere is causing more heat to be trapped. This is called the *enhanced* greenhouse effect.

The enhanced greenhouse effect has caused the average surface temperature of the Earth to rise 0.76°C since 1850.

This may not sound like much, especially since the temperature in a classroom can change by 10°C or more in one day. But the *average* temperature of the whole planet does not change like the temperature inside a classroom. In fact the global average temperature is very stable, and would not change 10°C over a day, month, year, decade or even thousands of years!

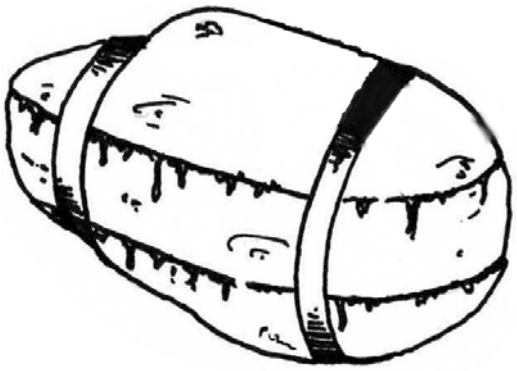
Can you make a model of an ice core from potato?

Climate change concepts

- Samples of ice frozen thousands of years ago provide information about our climate.
- Predicting global change requires models based on this information.

What you'll need

- 1 potato
- Rubber band
- Food colouring
- Knife
- Apple corer



Time required: 15 min

What to do

1 Cut the potato lengthways in one or two places so you end up with two or three sections of potato.
2 Take the bottom piece and add a drop of food colouring to the cut surface.
3 Place the middle section on top, and add a drop of colouring to it.
4 Sit the last piece on top and put a rubber band around the whole potato to hold the pieces together. You now have a model of a glacier.
5 Using the marker, label four quadrants on the potato.
6 Push the corer all the way through the potato. Gently remove the corer with the core intact.
7 Each person in your group should take an "ice core". Measure (in millimetres) from the top surface to the coloured line(s). How does the coloured area change from top to bottom?
8 Draw a picture of the ice core sample, include measured numbers in millimetres.
9 Draw the top of your potato showing your group's sample sites taken from quadrants I though 4. Again, indicate measured depths in millimetres.

What's happening in this activity?

A corer is used to make a model of an ice core from potato. Depending on the number of cuts in the potato, the core will either have 1 or 2 darks bands of colour. This is like the banding observed in ice cores, except in a real ice core there would be thousands of bands – each one representing a summer and winter of previous years.

What's happening across the Earth?

Ice cores thousands of meters long have been drilled from Antarctica. These have layers of snow deposited over the last 650 000 years. Once an ice core is obtained, tiny air bubbles trapped in the ice when it was frozen are examined. Ice cores from Antarctica show us that the amounts of carbon dioxide and methane currently in our atmosphere are the highest recorded in 650 000 years.

Models help people better understand complex scenarios. The long climate history in ice cores has given scientists a large amount of data that they use to build models about what will happen in the future.

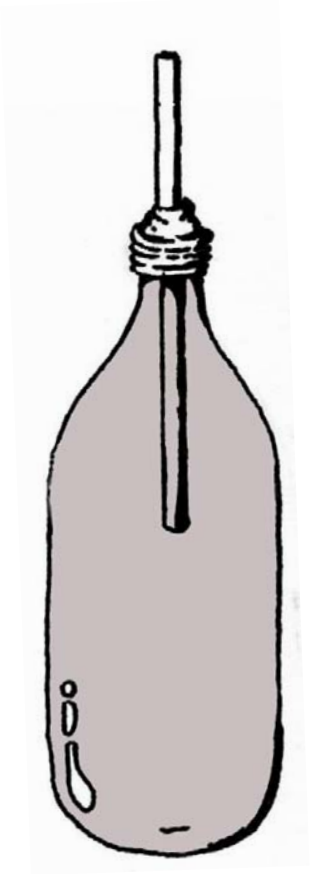
Can you make a water fountain using heat?

Climate change concepts

- Oceans are absorbing a lot of the heat from our warming atmosphere.
- Rising sea levels are in part caused by ocean warming.

What you'll need

- A plastic bottle
- Blu Tack or plasticine
- Straw
- Food colouring
- Something to warm the water (e.g. a lamp, sunny spot or warm water)



Time required: 30min

What to do

1 Fill a bottle with water so it is about 3/4 full and add some food colouring.
2 Use the plasticine or Blu Tack to form a seal around the straw so that about half the straw is sticking out the top of the bottle and some of the straw is sitting in the water.
3 Place the bottle under a lamp or in the sun or stand the bottle up in a container of warm water. If using warm water make sure the bottle is 2/3 submerged.

What's happening in this activity?

Most materials expand when they are heated. The water in the bottle expands as they warm creating a larger volume. Because the opening of the bottle is sealed, the only way for extra pressure to release is to push water up the straw.

What's happening across the planet?

The increase in greenhouse gases affects the temperature of the oceans as well as the atmosphere. Sea surface temperatures (SST) have been increasing over the past 100 years.

As the oceans become warmer, sea water expands. Thermal expansion contributes to the rise in sea levels. For the past 3000 years global sea levels have been relatively stable. Since the 1800s sea levels have risen, last century the ocean rose 15 cm.

As the atmosphere becomes even warmer, the oceans will continue to absorb this heat and expand causing sea levels to keep rising. The temperature of the ocean varies with location and depth. The large amount of heat the ocean can store means that it will be some time before the full effects of surface warming are felt throughout the depth of the ocean.

Can you melt ice to raise the sea?

Climate change concepts

- Global warming melts ice on the Earth's surface, this affects global sea levels.
- The melting of glacial ice and sea ice will affect sea levels differently.

What you'll need

- A small clear container
- Potato
- 3 ice cubes
- Water
- Marker pen
- Knife

Time required: 30 min

What to do

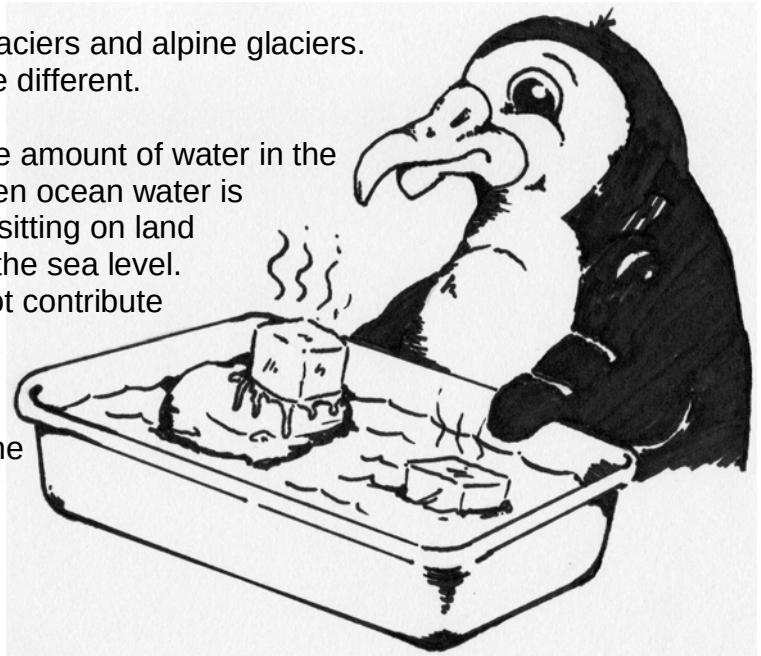
1 Cut a small section of potato big enough to hold an ice cube. This potato is the mountain.
2 Cut a second small section of potato that is flat - this is the Antarctic land mass.
3 Place the mountain and Antarctic land in the container and pour in enough water to just cover the flat piece.
4 Put an ice cube in the water. This represents Arctic sea ice.
5 Mark the water level on the side of the container and wait for the Arctic ice to melt. What happens?
6 Put an ice cube on top of the flat piece that is slightly underwater.
7 Watch to see what happens to the water level as this ice melts and enters the ocean.
8 Mark the new water level and place an ice cube on the mountain.
9 Wait for this last ice cube to melt.

What's happening in this activity?

The water does not increase when the floating ice melts because the water is already supporting the volume of this ice. The ice sitting on the Antarctic continent and the mountain ice cause the water level to rise as they melt. The volume of these ice cubes is not being supported by the water because they are sitting on land.

What's happening across the planet?

Global warming is melting polar sea ice, polar glaciers and alpine glaciers. The effect of this ice melting on sea levels will be different.



The main cause of sea level change is due to the amount of water in the ocean increasing or decreasing. This occurs when ocean water is exchanged with water stored on land. When ice sitting on land melts, water runs off into the oceans increasing the sea level. Melting of Ice that is floating on the ocean will not contribute to sea level change.

Sea levels rose 3.3 mm per year from 1990 to 2006. Arctic sea ice has shrunk 3 to 5% since the 1950s. In Antarctica and Greenland, large ice sheets are showing signs of global warming related change.

Is the ocean like soft drink?

Climate change concepts

- The ocean has absorbed fifty percent of the carbon dioxide emitted by humans from burning fossil fuels.
- The ability of the ocean to absorb carbon dioxide will be reduced as the ocean becomes warmer.

What you'll need

- 2 bottles of soda water
- Warm water or a sunny spot
- A fridge or some ice

Time required: 15 min

What to do

1 Put one soda bottle, unopened, in some warm water or in a sunny spot outside.
2 Put the other bottle in the fridge or in some icy or cool water (do not place bottle in freezer).
3 Leave for 15 min.
4 Open the cold bottle of soda water.
5 Carefully open the warmer bottle of soda water.
6 Did the soda water act the same way each time?

What's happening in this activity?

The soda water contains dissolved carbon dioxide – which makes it fizzy. The warmer the soda water is, the less carbon dioxide it can hold because the carbon dioxide is less soluble at higher temperatures. When the bottle is heated, and then opened, a lot of the carbon dioxide is released. The cooler soda water is able to hold more dissolved carbon dioxide, and so not as much is released when you open the bottle.

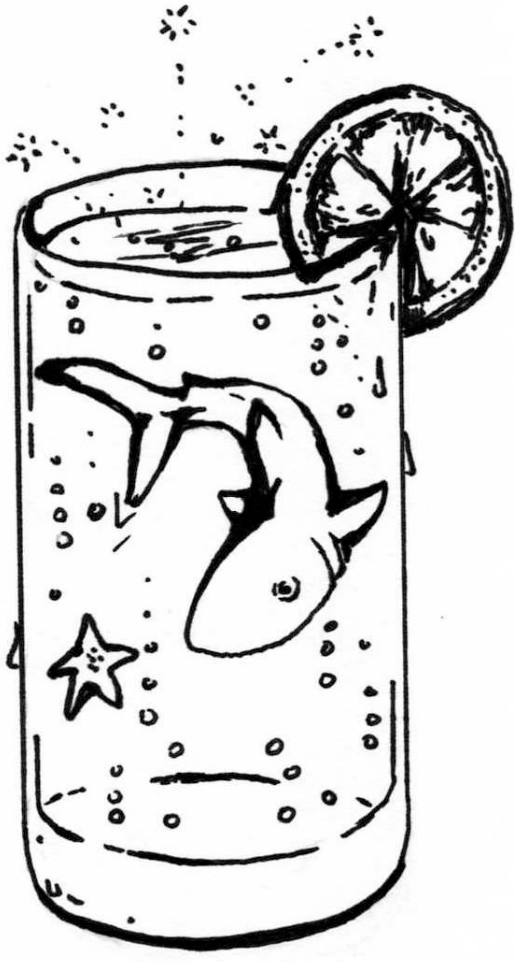
What's happening across the planet?

Things that absorb greenhouse gases, like trees and the ocean, are called carbon sinks. Things that release greenhouse gases, like farm animals, forest fires and power plants, are called carbon sources.

The ocean has absorbed 50% of our carbon dioxide emissions so far, preventing that carbon dioxide from staying in the atmosphere and contributing to global warming.

The ability of the ocean to do this is affected by temperature just like the soda water. The warmer the ocean gets, the less carbon dioxide will become dissolved in it. Also, the carbon dioxide the ocean has dissolved so far will start to be released.

So far the ocean has helped keep the planet cooler than it would be if all those greenhouse gases were left in the atmosphere. It has been acting as a carbon sink. As the ocean warms, it might become a carbon source – releasing greenhouse gases and accelerating global warming.



Is the ocean becoming more acidic?

Climate change concepts

- The ocean absorbs large amounts of carbon dioxide from the atmosphere, and this helps to limit global warming.
- Increased carbon dioxide in the ocean makes sea water more acidic and this affects organisms that live in it.

What you'll need

- 2 pieces of chalk (dustless or dusty)
- Lemon juice
- Clear plastic cup

Time required: 10 min

What to do

1 Put a piece of chalk in the cup and cover with
2 lemon juice.
3 Leave for 10 min, what is happening to the chalk?
4 Pull the chalk out and break it in half.
5 Now take a piece of chalk that was not put in lemon juice and break it in half.
6 Was one piece of chalk harder to break than the other?

What's happening in this activity?

Lemon juice contains citric acid and is therefore slightly acidic. The chalk contains calcium and is not very acidic; actually it is the opposite and is slightly alkaline.

When the lemon juice is added to the chalk they react. This reaction between the chalk and lemon juice dissolves the chalk.

What's happening across the planet?

When carbon dioxide is absorbed by the ocean, it makes sea water more acidic.

The pH of a solution indicates how much acid is present in it. The pH of lemon juice is about 2.5. Sea water has a pH of 8.1, but the ocean is becoming more acidic and the pH has dropped 0.1 units since humans started emitting large amounts of carbon dioxide.

While this may not sound like much, it actually means that there is a lot more acid in the water. It is predicted that over the next 100 years the pH will continue to fall to between 7.8 and 7.9. Again this does not sound like much, but this change means there will be 30% more acid molecules in sea water.

This increase in acidity will affect many plants and animals that live in the ocean. Animals that use calcium to build their skeletons like star fish and molluscs, will find it harder to get extract calcium from the water. If the ocean becomes too acidic it will start to dissolve the shells and corals living in it. If their shells weaken they may not be able to survive.

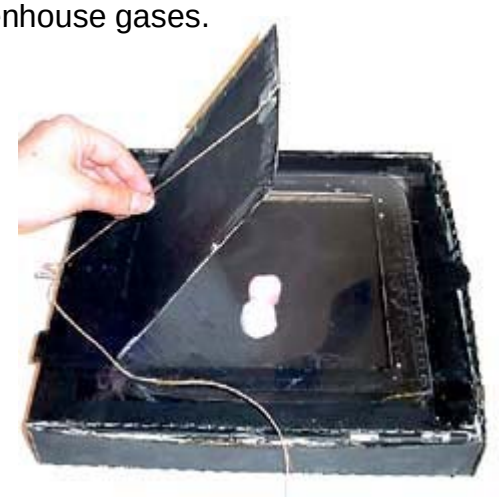
Can you use energy from the sun to cook?

Climate change concepts

- Making electricity using coal is not renewable and releases greenhouse gases.
- Solar energy is renewable and does not release greenhouse gases.

What you'll need

- Pizza box (large or small)
- Newspaper
- Sticky tape
- Scissors
- 2 overhead transparencies
- Aluminium foil
- Ruler



Time required: 60 min

What to do

1 Draw a rectangle on the lid of the pizza box that starts 3cm in from each edge.
2 Cut two long sides and one short side of the rectangle you just drew.
3 Lift up the square flap and make a crease at the hinge.
4 Cover the underside of the flap (the side that faces in) with aluminium foil. Secure it in place with some tape. Now line the inside of the pizza box with aluminium foil.
5 Take an overhead transparency and cover the opening in the lid. Secure it with some tape and then attach another piece over the top of the first one.
6 Open the box and roll up some newspaper and tape this around the inside edges of the box for insulation.
7 The flap needs to be adjusted so that sunlight can be reflected off the foil and into the box. Use the ruler or a stick to prop the flap up, or use string to anchor it.
8 Try warming, melting or cooking some food.

What's happening in this activity?

The aluminium foil reflects the Sun's light into the oven. The two sheets of plastic and the newspaper insulate the oven to trap the heat inside. The plastic provides good insulation and the newspaper reduces the amount of heat escaping from the sides of the box.

What's happening across the planet?

Most of the global warming since the mid 20th century is due to increased concentrations of greenhouse gases in the atmosphere. Greenhouse gases are released when fossil fuels are burnt. The greatest source of carbon dioxide is electricity production which involves the burning of coal, a fossil fuel.

Most of Australia's electricity comes from coal-fired power stations. Around the world, more and more electricity is being made using solar energy. Solar energy is light and heat energy from the sun. Making electricity from solar energy does not release greenhouse gases and is renewable. The benefit of a renewable energy is that once the solar panel is built it does not need fuel, like a coal-fired power station does.

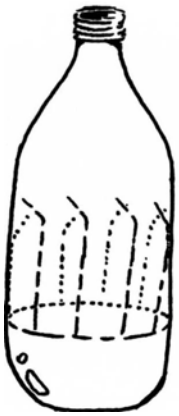
Can you design the best wind turbine?

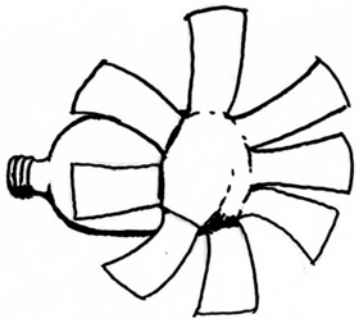
Climate change concepts

- Making electricity using coal is not renewable and releases greenhouse gases.
- Wind power is renewable and does not release greenhouse gases.

What you'll need

- Thin cardboard
- Templates
- Ruler and pencil
- Scissors
- Drawing pins
- Two erasers or corks
- A plastic bottle (e.g. soft drink bottle)
- Fan





Time required: 30 min

What to do

1 Use the templates to cut two wind turbines of different shape and size.
2 Cut along the broken diagonal lines.
3 Make five small holes and then fold the paper so that all the holes are aligned.
4 Put a drawing pin through the holes and then push into the eraser or cork.
5 Hold one pin wheel in front of a fan and count the number of revolutions in 10 seconds. Now try with the other pinwheel, which is faster? What if you change the bend in the blades?
6 Now make wind turbine out of plastic. Cut the bottom off the plastic bottle.
7 Draw lines on your bottle as in the picture above.
8 Cut along these lines and bend the strips back to form the turbine's blades.
9 Hold the turbine in front of a fan. Put a pencil in mouth of the bottle so it can spin freely. Count the number of revolutions in 10 seconds.

What's happening in this activity?

The shape and size of the blades on a wind turbine affect how fast it spins. Larger blades spin faster than smaller blades. The plastic blades are heavier but stronger.

What's happening across the planet?

Most of the global warming since the mid 20th century is due to increased concentrations of greenhouse gases in the atmosphere. Greenhouse gases are released when fossil fuels are burnt. Carbon dioxide is the most common greenhouse gas released by human activity. The greatest source of carbon dioxide is electricity production which involves the burning of coal, a fossil fuel.

Most of Australia's electricity comes from coal-fired power stations. Around the world, more and more electricity is being made from wind. About 2% of the solar energy that reaches Earth is converted into wind energy. Winds result from unequal heating of the Earth's surface. Some parts become warmer than others, heating the air. This air expands and rises. Cooler air replaces the warmed air, creating movement and causing wind. Wind is a renewable source of energy. The benefit of renewable wind power is that once wind turbine is built it does not need fuel, like a coal-fired power station does.

Can you peel the atmosphere?

Climate change concepts

- The atmosphere is very thin compared to the width of the Earth.
- The amount of greenhouse gases in the lower atmosphere is increasing.

What you'll need

- 1 apple
- Apple peeler
- Knife

Time required: 10 min

What to do

1 Cut the apple in half.
2 Measure the width of the skin and the width of the flesh.
3 Now peel the skin off.

What's happening in this activity?

The thickness of an apple's skin compared to the whole apple is about the same proportion as the Earth and its atmosphere.

What's happening across the planet?

The atmosphere is often portrayed as having a size comparable to Earth. While it is many kilometres high, it is actually 800 times smaller than the width of the Earth!

The Earth's atmosphere is a thin layer of gases surrounding the Earth. The atmosphere becomes gradually thinner the further it is from the Earth's surface. Greenhouse gases accumulate in the lower 20kms of the atmosphere, called the Troposphere. Gases in the Troposphere are well mixed because global currents of air move oxygen, pollution and greenhouse gases from one region to another. This means that greenhouse gases released in one area mix with those released from another area.

The global climate is changing, because of an increase in greenhouse gases in the atmosphere. The increase in greenhouse gases thickens the natural warming layer around the Earth.

Can you model wind in a bottle?

Climate change concepts

- A global system of air currents and wind move gases around the Earth.
- Because of this mixing, a reduction in greenhouse gases in one country or area helps other countries and areas.

What you'll need

- A small clear plastic bottle or a clear balloon
- Liquid hand soap (any will do as long as it has glycol stearate in it)
- Blue food colouring
- Water

Time required: 10 min

What to do

1. Fill the bottle ¼ full with hand soap. If you are using a balloon squirt as much hand soap in as you can.
2. Add 1-2 drops of food colouring.
3. Fill the bottle or balloon up with just a trickle of water so the soap and water do not mix and form foam.
4. Fill the bottle all the way to the top so there is no air, and put the lid on. If using a balloon let all the air out before tying it off.
5. Twirl and shake the bottle or balloon to see smooth streaks and turbulent swirls.

What's happening in this activity?

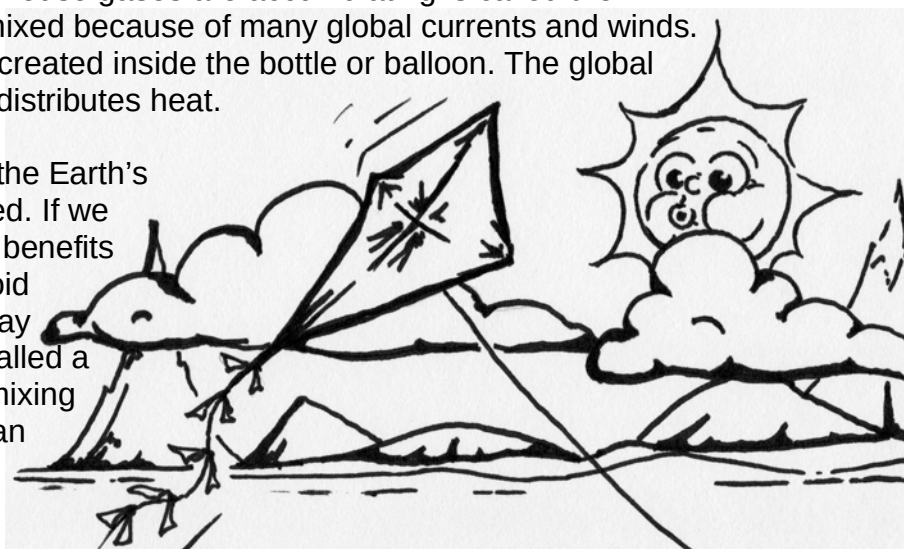
As the bottle or balloon is twirled, the mixture of hand soap and water inside drags against the inside wall and starts to spin. If you rotate the bottle or balloon slowly, you may see smooth currents that flow parallel to each other. If you spin and shake rapidly, the current becomes more complex, producing many swirls and eddies.

What's happening across the planet?

Not all countries produce the same amount of greenhouse gases - some countries use less or more coal generated power than others. So why hasn't the temperature gone up only in areas where the emissions of greenhouse gases is high?

The part of the atmosphere where greenhouse gases are accumulating is called the Troposphere. The Troposphere is well mixed because of many global currents and winds. This pattern of air movement is like that created inside the bottle or balloon. The global movement of gases in the Troposphere distributes heat.

Carbon dioxide completely disperses in the Earth's atmosphere within 1 year of being emitted. If we reduce greenhouse gases one region, it benefits the whole planet. If someone cannot avoid releasing greenhouse gases, they can pay someone else to do it for them. This is called a greenhouse gas offset and because of mixing of gases in the atmosphere that offset can be from anywhere in the world!



Extra Information and Activities

The greenhouse effect

The greenhouse effect refers to the way that the atmosphere traps heat, maintaining the temperature of the Earth's surface at a level required to support life. Greenhouse gases are responsible for trapping this heat and the part of the atmosphere where they are found can be thought of as a blanket that warms the planet. Energy from the sun reaches our atmosphere, some of this energy is reflected back towards space and some reaches the Earth's surface. The energy hitting the surface is absorbed by trees, soils, the ocean and buildings and converted to heat energy (infra-red energy). This energy is re-radiated into the atmosphere where some is absorbed by greenhouse gases and some escapes into space. The energy absorbed by greenhouse gases is then emitted back towards the Earth.

What's happening across the planet?
The concentrations of these greenhouse gases are increasing because of human activities like burning fossil fuels, tree clearing and large-scale farming. More heat-trapping gases in our atmosphere means that more heat is trapped near the surface of the Earth.

Eleven of the last 12 years have been the hottest years since humans started measuring the weather. The oceans have absorbed more than 80% of this extra heat, and over the last 50 years, the temperature of the oceans has increased. Even water up to 3000 m deep has become warmer.

A warmer ocean has more energy which causes this water to expand, raising sea levels. A warmer atmosphere can hold more water, increasing evaporation in certain areas and drying them out.

A warmer ocean and atmosphere will change many aspects of our climate. Climate change will affect the number of storms and fires and the amount of rain and drought. The Earth is a large interconnected system, with many parts that all depend on each other. A change in one thing affects many others. This is why climate change is better thought of as *global change* – indicating that global systems, not just the climate, are changing.

It's not the end of the Earth!
Here are how all the terms used in climate change science and the media fit together:

natural greenhouse effect
↓
enhanced greenhouse effect
↓
global warming
↓
climate change
↓
global change

Large and complex changes are occurring now. The size of change means that sometimes people become fearful of the future and decide that there is nothing they can do to help

minimise and adapt to our changing planet. The complexity of the science behind the change means many people do not understand the causes and cannot workout how to fix it.

If you are unsure of an aspect of climate change, there are plenty of ways to find out more. The resource list at the back of this book is a start.

If you are worried that the problems of climate change are too big for one person to make any difference, then you need to think again! Millions of people are making small and big changes to their lives to help reduce greenhouse gas emissions and to better adapt to climate change. The types of things you can do are endless. Some things include calling your electricity company and choosing renewable electricity for your home, turning your air conditioner or heating down, using low-energy light bulbs and recycling.

The most important thing you can do is keep positive! We have managed to deal with some pretty big environmental problems before – like when the world got together and banned the use of certain chemicals that caused the ozone hole.

Global change activities

- Think about one day this week and make a list of all the activities you did. Now look through your list and tick those that required fossil fuels. Did you get driven to school? Did you watch some TV after school? Did you chat on MSN?

- Now look at your list and circle those that resulted in the emission of some greenhouse gases. Did the apple you eat get trucked from a farm to the grocery store? What about your plastic lunchbox? Where were your shoes made, did they come on a ship from overseas?

- Discuss whether a greenhouse and the Earth's atmosphere act the same way. Does the term 'greenhouse' accurately represent the role of the atmosphere? Consider that greenhouses work mainly by preventing warm air inside from mixing with cool air outside the greenhouse.

Greenhouse gases and climate change

A greenhouse gas is any gas that absorbs infra-red radiation causing heat to be trapped in the atmosphere. There are many greenhouse gases in our atmosphere:

- Water vapour
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_20)
- Halogenated fluorocarbons H CFCs
- Ozone (O_3)

The main greenhouse gas that influences warming is naturally occurring water vapour. Water vapour is the most abundant greenhouse gas. The amount of water vapour in the atmosphere is variable and human activities have little direct impact on its amount in the atmosphere.

The main greenhouse gases that humans do affect are carbon dioxide, methane and nitrous oxide. The concentration of carbon dioxide in our atmosphere has increased since Industrialisation from 280 parts per million (or ppm) to 379 ppm in 2005. The increase is because of burning fossil fuels and tree clearing. Greenhouse gases are measured in parts per million (ppm), which is a ratio of how much greenhouse gas there is in 1 million parts of air. Since carbon dioxide is now at 379 ppm, this means that if you took 1 million of the molecules that make up dry air, 379 of those molecules would be carbon dioxide. Another way is to imagine that if you could gather 1 million litres of dry air – meaning the water has been removed – 379 litres of that would be carbon dioxide.

The amount of methane has also increased in the last two centuries from 715 parts per billion (ppb) to 1774 ppb in 2005. This methane has also come from burning fossil fuels, but has mostly come from farm animals like cows and sheep that burp and fart methane when digesting grass.

The last major greenhouse gas that humans have released more of is nitrous oxide. The amount of nitrous oxide has increased from 270 ppb since before Industrialisation to 319 ppb in 2005. Nitrous oxide is released into the atmosphere mainly from the use of fertilisers.

What's happening across the planet?
The current amount of carbon dioxide and methane in our atmosphere is above the natural range measured over the last 650 000 years. It is predicted that these gases are going to continue to rise in coming decades because humans are still burning fossil fuels, clearing trees and farming.

Carbon dioxide is the most talked about greenhouse gas because it is the one we are producing most. However, other greenhouse gases such as methane, nitrous oxide and even water vapour have a greater warming effect than carbon dioxide.

Carbon dioxide is produced when we burn fossil fuels to make electricity, drive our cars or burn oil or gas. Currently, the most common way to make electricity is to burn coal, and this releases large amounts of carbon dioxide into the atmosphere. Methane is also produced when fossil fuels are burnt, but mainly comes from the burping and farting of farm animals. Nitrous oxide is produced when fossil fuels are burnt but also arises when chemical fertilizers are applied to crops.

These greenhouse gases trap different amounts of heat and hang around in the atmosphere for different amounts of time. Once emitted, carbon dioxide stays in the atmosphere for 200 to 450 years. Methane only lasts for 9 to 15 years but actually causes 23 times more warming than carbon dioxide (over 100 years). Nitrous oxide lasts for 120 years in the atmosphere and causes 296 times more warming than carbon dioxide!

It's not the end of the Earth!

Many countries, companies and individuals are trying to reduce the amount of carbon dioxide they are emitting. In 1997 the Kyoto Protocol was drafted and eventually adopted by many countries. The Kyoto Protocol attempts to get developed countries to reduce their greenhouse gas emissions. These countries are now using more and more renewable energy including solar, wind, tidal, geothermal and hydropower.

Likewise, many companies and organisations are reducing greenhouse gas emissions that their business generates by choosing to use renewable electricity, modifying their buildings to use less heating or cooling, and recycling.

Reducing greenhouse gases is not the sole responsibility of individuals and families, government and business must also play a role. But everyday people can make changes to their everyday lives and make a big difference. Often the problems of global warming, climate change and global change seem too big to fix – but remember that there are billions of people living on this planet – and together small changes quickly add up to big ones. Anyone can turn their TV off at the wall, choose to use renewable electricity, wear an extra jumper in winter, ride short distances instead of driving and recycle.

Global change activities

- Do you know how much carbon dioxide is emitted from the things you do? You might be surprised. Go to: http://www.epa.vic.gov.au/GreenhouseCalculator/calculator/default.asp

- Create a transportation log and collect information for one week on the use of your family car. Some things to record are lengths of trips, reasons for trips, fuel used, distance travelled. Write up your results and then pool the results of the whole class. Identify some trips that could have been made on foot or with a bike? Are there other ways to reduce car use? Compile the top 5 ways to reduce car use and distribute in the next school newsletter.

Measuring global warming

At the same time as the Earth has been warming, the amount of carbon dioxide in the atmosphere has also increased. From 1900 to 1950 most global warming was due to natural events like solar or volcanic activity. From 1950 until today, the amount of warming cannot be explained by natural events. Instead, the build up of greenhouse gases, like carbon dioxide, is causing the Earth to become warmer. As well as measuring the temperature and carbon dioxide now, scientists are able to measure the temperature and carbon dioxide of the Earth over hundreds of thousands of years ago.

Because humans were not taking measurements of the atmosphere and oceans until recently, we have to use other records. Common ways of doing this are by looking at the tree rings of old trees, layers of soil sediment or at samples of ice taken from deep underground. Samples of ice are called ice cores because they are long cylindrical pieces of ice. They are collected in a similar way as you would core an apple – except ice cores can be thousands of metres long and ice is much harder to core than apple!

Once an ice core is obtained, tiny air bubbles trapped in the ice when it was frozen are examined. From these little bubbles of air scientists can tell the temperature of the atmosphere that the air came from and also the amount of carbon dioxide floating around at the time the air became trapped.

The deeper the bubble was trapped in the ice core, the older it is. By using ice cores, scientists have been able to measure the temperature and carbon dioxide of the Earth up to 740 000 years ago! This activity demonstrates the use of ice cores.

What's happening across the Earth?
Ice cores thousands of meters long have been drilled from Antarctica. These cores contain climate information. Dust, ash, bubbles of gas and radioactive substances can all be found in ice cores. By measuring, these scientists can work out the temperature, ocean volume, amount of rain and the chemicals in the lower atmosphere.

Ice cores from Vostock in Antarctica show that atmospheric temperature and carbon dioxide have risen and fallen together over the last 420 000 years. The Vostock ice core also tells us that the amount of carbon dioxide and methane in our atmosphere are higher now than they have ever been over this same period. Another finding is that the current rate of greenhouse gas buildup in our atmosphere is the fastest on record.

Scientists use models to work out what will happen to the global climate in the future. Models help people better understand complex scenarios. Sometimes, like the Earth's climate, a thing is too large or complex to be easily observed from all sides. Models of the global climate are computer generated and based on mathematic formula. This allows the parts of the climate to be investigated and experimented upon.

The long climate history in ice cores has given scientists a large amount of data they use to build models about what will happen in the future. Current climate models predict that the Earth will continue to become warmer and that greenhouse gases will continue to build up and cause this warming.

It's not the end of the Earth!
The fast rates at which greenhouse gases are being released and causing warming does not mean that it is too late. Hundreds of people, companies and governments are working on solutions to the problems caused by global warming and global change.

It was lots of people doing everyday things, like driving their car to the shops, or using electricity that contributed to global warming. And it will be lots of everyday people doing everyday things, like walking to the shops and turning their TV off at the wall, that will help reduce the greenhouse gases being released and minimise the temperature rise in coming decades.

Australian scientists have contributed to our understanding of climate change and modelling. Our location near Antarctica means that Australian researchers are often involved in the collection of ice cores, measuring climate in Antarctica and developing models that explain the effects of global warming.

The CSIRO has made a complex climate model that is actually used by the Intergovernmental Panel on Climate Change to determine what the future climate will be like. CSIRO's model is a leading tool that can investigate ice surfaces, temperature changes and changes in the biosphere. CSIRO was able to build this model by using satellites to collect data on climate from space, collecting information from commercial boats that use the ocean and by recording their own data on expeditions.

Global change activities

- Can you build another model of an ice core? Use different coloured and flavoured liquids (like cordials) and freeze them in layers on top of each other. Examine the ice core; make measurements of the different layers. Taste the different layers, do they taste the same? Are there any differences in texture?

- After discussing the evidence for global warming have students brainstorm ways of sharing this evidence with others. One way could be to design a poster or a colourful bumper sticker for a car. These may then be displayed on school bulletin boards, shop windows or vehicles.

- What is an ecological fingerprint? A Melbourne-based organisation called Vox Bandicoot has created an innovative new tool to help people visualise their relationship with the environment. Until now people have been calculating their ecological footprint – which tells someone how many resources their way of living requires. Research has shown that when people realise how many resources they actually use they can become worried that the problem is too big and that change is too hard.

  So Vox Bandicoot thought of a new way at looking at climate change and how people can help. The program is based on a very positive message: a footprint is left behind and a fingerprint is left when reaching forwards. The eco fingerprint uses different types of habitats and behaviours to help people conceptualise their relationship with the global environment and the environment around them. So what is your ecofingerprint? Go to: http://www.voxbandicoot.com.au/ecofingerpint

Sea level rise – warming water

Oceans are divided into separate areas like the Pacific Ocean or Atlantic Ocean, but the world's oceans are actually a single connected body of salty water. Oceans cover 70% of the surface of the Earth and nearly half of this water is in areas that are over 3 km deep.

The temperature of the ocean varies with location and depth of water. Sea water closer to the equator is warmer than water near the poles, and deeper water is cooler than water near the surface. The ocean can absorb and store more heat than any other component of the Earth's climate.

The increase in global temperature is a combined measure of the atmospheric temperature and the temperature of the top few metres of ocean (called the Sea Surface Temperature). This warming has resulted in a sea level rise of 15 cm in the last 100 years.

The rising level of the oceans is due to two main factors – the melting of glacial ice in Antarctica, Greenland and alpine areas, and the expansion of the sea due to direct heating. This activity demonstrates the expansion of water as it becomes warmer.

What's happening across the planet?
For the past 3000 years, global sea level has remained stable, but since the end of the 19th century, tide gauges have detected global sea level rises.

During the past decade oceans have risen 3.3 mm per year, and ocean warming and expansion has caused about half of this rise.

The rate of climate change can be lowered if the rate at which heat is transferred from the surface to deeper waters is increased. However, this then means that the rate of sea level rise would be more rapid.

Surface water mixes with deeper water via large oceanic currents. These currents are also responsible for mixing ocean water between different parts of the Earth. As the oceans have become warmer, the water has expanded, and this thermal expansion has contributed to the rise in sea levels we are now seeing.

As the atmosphere becomes even warmer, the waters will continue to absorb this heat and expand, causing sea levels to keep rising.

The large amount of heat the ocean can store means that it will be some time before the full effects of warming are felt throughout the depth of the ocean.

Global change activities

- What will happen to corals that live in the Great Barrier Reef when they are under more water? Discuss the implications for sunlight reaching the corals.

- Do some countries have a responsibility to help others? Two thousand of Indonesia's islands are expected to become completely covered by sea water. Where will these people move to? People that have to move because of environmental or climatic events are called environmental refugees.

- Can you design something that would keep the rising sea from washing away houses or our beaches? How big is your machine? How could you use it in areas that will be most affected.

Sea level rise – melting ice

Ice is found on every continent and forms different structures. Permanent ice that forms over land is called a glacier. Glaciers can be very large such as the ice sheets in Antarctica or Greenland.

Glaciers are not only found in polar regions. Alpine glaciers can form in areas where it is cold enough for water to freeze, such as at high altitudes or in areas close to the polar regions. Alpine glaciers can cover part of a mountain, a mountain range or a volcano.

Unlike glaciers, sea ice is floating and not attached to land. Most of the ice around the North Pole is sea ice. Some sea ice is always present, but each winter and autumn new ice forms from 1 to 3 m thick and then melts in the summer. Like glaciers, sea ice can also form large ice sheets.

Despite the solid appearance of glaciers and sea ice, they are always changing. They move in response to gravity, rain, and changes in the seasons. This means that glaciers move from central areas to the sea, where they eventually thin, break off and then melt. This loss of ice is balanced by an accumulation of ice in the central areas where rain freezes and snow becomes compacted.

What's happening across the planet?
It was thought that melting from Antarctica and Greenland was not contributing a great deal to sea level rise. Recently it was found that the melting of these ice sheets has been greater than expected, resulting in greater rises in global sea levels.

Observations so far have shown that Arctic sea ice has shrunk by 3 to 5% since the 1950s and by 2050 may be completely ice free during summer. In Antarctica and Greenland, large ice sheets are showing signs of global warming related change: in 2002, the Larsen B ice shelf (3250 km^2 of ice) broke away from Antarctica. Alpine glaciers are also showing signs of change right across the world with melting rates doubling since 1980.

From 1990 to 2006 the global sea level rose 3.3 mm per year. This rate is 25% faster than any rate in the last 115 years.

It's not the end of the Earth!
Melting glaciers, collapsing ice sheet and rising seas sound like pretty scary stuff. Often people become depressed by these changes and give up, but it is important to keep a positive outlook. The problem of climate change is big, but not too big that it cannot be fixed.

Rising seas from ice melts and thermal expansion is because of one factor – a warming Earth. We can do something about this warming, easily and as soon as you are ready. Reducing greenhouse gas emissions means putting less heat-trapping gases into the atmosphere and can be done by using renewable electricity, catching public transport, riding your bike or turning appliances off at the wall.

Reducing your greenhouse gas emissions can be fun and easy. Talk to your family and friends about it and see what ideas they have.

Global change activities

- Draw and colour in a map of Greenland. Use the internet to find out how much ice is likely to melt with future climate change, plot this on your map in a different colour. Think about the animals that use the areas that are going to melt. Pick an animal and consider how it will adapt to its new environment? What does this animal eat? Does it need other resources that will be affected by the ice melt?

- Inuit is the name given to people that live in the Arctic region. They have hunted for food and occupied the Artic tundra for hundreds of years. With the increased melting of Arctic ice, polar bears are going to be competing for space and resources with Inuit people even more. Design a strategy that manages this problem. Consider: can the polar bears be excluded? Can Inuit people shift to other food sources to limit interactions with polar bears?

- All the freshwater that enters the ocean will mix with the salty water of the ocean. This will affect the salinity of the surface sea waters. How will this affect the density of this water? Research the impact of this fresh and salt water mixing on ocean currents, like the Gulf Stream.

- Glaciers are popular places for tourists to visit. Imagine you are a local tour guide, and the glacier you take people to visit is disappearing. Design a brochure of the things that people will be able to do instead of seeing the glacier. Can you think of other ways that people can enjoy that area?

Acidic oceans

The evidence indicates that the acidification of the oceans is due to the human production of carbon dioxide from burning fossil fuels. The impacts of increasing acidity will probably vary regionally and therefore affect some areas more severely than others.

The process of acidification will affect the process of calcification. Many organisms that live in the ocean absorb calcium from sea water to make their skeletons and other structures. Large and small animals and plants such as starfish, molluscs, crabs, plankton, corals and algae all use calcium.

What's happening across the planet?
Sea water has a pH of 8.1, but the ocean is becoming more acidic and the pH has dropped 0.1 units since the industrial revolution. This may not sound like much, but actually means that there are 30% more acidic molecules in sea water. It is predicted that over the next 100 years the pH will continue to fall to between 7.8 and 7.9.

The ability of the ocean to do this is affected by temperature. The warmer the ocean gets, the less carbon dioxide will become dissolved in it. Also, the carbon dioxide the ocean has dissolved so far will start to be released.

It's not the end of the Earth!
The acidification of the ocean will not be reversible in our lifetimes. Scientists suggest that it will take tens of thousands of years for the chemistry of the oceans to return to the acidity of pre-industrial times. While we may not be able to reverse the change in the oceans, we can limit the amount of greenhouse gas we are releasing into the atmosphere. A reduction in greenhouse gas emissions means there will not be as much in the atmosphere to cause ocean warming and to be absorbed by the sea.

Greenhouse gases are easy to reduce. According to Al Gore's movie An Inconvenient Truth there are 10 key things anyone can do: use low-energy lights, drive less, recycle, have your car tyres at the right pressure, use less hot water, buy products with less packaging, turn your air conditioner and heater down, plant a tree and share your knowledge.

Global change activities

- You are a tourism operator and take people diving and snorkelling at your local reef. If not as many corals are found because the water is too acidic, what will you show your customers?

- Many microscopic organisms, called plankton use calcium. Often, these very small plants and animals form the very start of the oceanic food webs. If there are not as many plankton in the future, what will happen to other animals that eat them? Draw and decorate a food web that shows the plankton and all the other organisms that rely on them as a resource.

- Some species may evolve to live in a more acidic environment. Imagine that there are currently 20 species of coral on a reef, each one a different colour, but only 25% of coral species can survive in the new environment. Draw the new reef next to the old reef showing a change in the patterns of corals and their colours. How will warmer sea water affect this?

- Investigate the Earth's carbon cycle. On a map colour in major carbon sinks like forests and oceans and major sources of carbon. How will global change affect these stores and sinks? Write a "letter to the editor" outlining the role of the ocean as a carbon store and how it may turn into a carbon source.

Renewable energies

The greatest source of carbon dioxide from human activity is electricity production. In a coal-fired power station coal is burnt to heat water until the water turns to steam. The steam is forced under great pressure through a turbine. The turbine turns a generator, which produces the electricity. The steam used in this process is heated to 541°C. Producing this much heat requires a lot of coal to be burnt, releasing greenhouse gases.

Using coal to make power releases carbon dioxide, but the other reason that coal is not ideal is that is not a renewable resource. This means that the Earth has a certain amount of coal, and once it is gone we can not make more. There are many ways to make electricity that do not release carbon dioxide and that use renewable sources:

- Solar power uses sunlight
- Wind power uses wind
- Hydro power uses water from dams
- Geothermal power uses heat deep in the Earth's crust
- Tidal power uses the energy and movement of the tides

Nuclear power does not release carbon dioxide, but again, it uses a substance from the ground – Uranium – that cannot be renewed once it is used.

What's happening across the planet?
Solar cells convert sunlight into electrical energy. Thermal collectors convert sunlight into heat energy. Solar technologies are used in watches, calculators, water pumps, space satellites, for heating water, and supplying clean electricity to the power grid. There is enough solar radiation striking the surface of the earth to provide all of our energy needs.

More and more electricity is being made from renewable sources, like solar and wind. One benefit of renewable energies is that once the solar panel or wind turbine is built it does not have to be fuelled, like a coal-fired power station does. One problem with renewable energy is that we cannot control the amount of sunlight or wind in order to make the right amount of electricity. For this reason, many countries still mostly use coal to make their electricity and are even building new non-renewable power stations like nuclear power plants.

It's not the end of the Earth!
The use of renewable electricity is becoming more popular. Many companies and households are asking their electricity company to supply renewable electricity to them.

Nearly all of Australia's electricity comes from coal-fired power stations, meaning that tonnes of greenhouse gases are released every day. You can reduce the amount of electricity you use by switching your computer or TV off at the wall, unplugging your mobile phone charger after use and using a low-energy light bulb in your room. The power stations will only make power that people need, so if people need less power, less will be produced.

Global change activities

- Wind power involves using the wind to turn a turbine connected to an electricity generator. Have students contact a wind farm to inquire about the process of making electricity through wind power.

- Solar powered cars do not release greenhouse gases, but they look very different from everyday cars that run on petrol and release greenhouse gases. Draw a cartoon indicating their opinion on solar cars and whether there should be more research into them.

The atmosphere and trading carbon

The Earth's atmosphere is a thin layer of gases with different gases found in different areas. The atmosphere is not actually layered, like a cake, but does become gradually thinner further from the Earth's surface. Greenhouse gases accumulate in the lower 20 km of the atmosphere, called the Troposphere. Greenhouse gases in the atmosphere are well mixed because global currents of air move oxygen, pollution and greenhouse gases from one region to another. This means that greenhouse gases released in one area mix with those released from another area.

As well as mixing around the atmosphere, greenhouse gases are continuously being circulated between living things, oceans and the Earth's crust. This has been well studied for carbon dioxide, and we know that of the carbon dioxide released by human activities half remains in the atmosphere with the rest absorbed by plants, the ocean and soils. Things that absorb carbon like trees and the ocean are called carbon sinks. Things that release carbon dioxide like power plants and farms are called carbon sources.

An important step in lowering greenhouse gas emissions is the trade of emissions between people, companies and nations. If new technology is not available, and greenhouse gases have to be produced, these greenhouse gases can be offset. Offsetting the greenhouse gases means reducing greenhouse gases somewhere else. For example, an individual can offset the greenhouse gases produced by their car by buying a reduction in greenhouse gases from another company that might produce solar power or plant trees.

It's not the end of the Earth!
People, companies and nations are buying greenhouse gas offsets. A reduction in one area, benefits the whole planet because of the global mixing of greenhouse gases and heat in the atmosphere.

The first step in reducing greenhouse gases should be to avoid burning fossil fuels or clearing trees, but sometimes replacement technologies are not available and greenhouse gas offsets are used. This can be a very successful system where some businesses make money by emitting less greenhouse gases.

Greenhouse gas offsets can include planting trees to soak up carbon dioxide out of the atmosphere or investing in renewable electricity programmes such as wind or solar power. Many companies are operating in Australia that help people offset their greenhouse has emissions.

Global change activities

- Form into groups and discuss what the world would be like if we continue to use oil and coal at our current rate. Will people's health change? Will the oceans or forests change? What will happen to people's lifestyles? After thinking about these, prepare a scenario showing conditions in your town 15 years from now. You could make a diorama, write a short play or design a poster. What ever you make, it should show what you think people's reactions will be to the changes above.

- Look through a newspaper and find an article on climate change or renewable power. How many viewpoints are raised in the article? Does the article lean towards economic or environmental arguments? Do these have to be mutually exclusive sides of the coin when it comes to adapting or mitigating climate change?

Resources for Educators

Science Online

- David Suzuki Foundation: www.davidsuzuki.org
- BBC Weather: www.bbc.co.uk/climate/
- Global Cool: www.global-cool.com
- Royal Society: www.royalsoc.ac.uk/landing.asp?id=1278
- Real Climate: www.realclimate.org/
- New Scientist: http://environment.newscientist.com/

Type climate change education into Google and it will tell you there 'are about 60 million pages'!

Communication Online

- Climate Challenge: www.climatechallenge.gov.uk/

Education Resources Online

- Classroom Earth: www.classroomearth.org
- New Economics Foundation: www.neweconomics.org Download the Democs cards, activity sheets and teachers' guide for free.
- Global Cool: www.global-cool.com
- Friends of the Earth: www.climatesafe.co.uk/
- Climate Change Education: www.climatechangeeducation.org
- Education in sustainability: ARIES (Australian Research Institute in Education for Sustainability) have reports and case studies at: http://www.aries.mq.edu.au/publications.htm
- NSW Greenhouse Office: www.greenhouseinfo.nsw.gov.au/

Other programs

- *Schools Climate Change Initiative* launched in 2007 by NSW Department of Education and Training. Read about it at: http://www.curriculumsupport.education.nsw.gov.au/policies/envired/index.htm
- *Sustainable Schools Initiative* managed by the Australian Government Department of Environment and Water Resources. Read about it at: http://www.environment.gov.au/education/sustainable-schools/index.html

Books

- Tim Grant and Gail Littlejohn 2001 *Teaching About Climate Change: Cool Schools Tackle Global Warming*. Toronto: Green Teacher. Available at: www.vaee.vic.edu.au
- Greenhouse Activities Primary and Greenhouse Activities Secondary. Workbooks developed in Australia and available at: www.vaee.vic.edu.au
- Australian Greenhouse Office has heaps of materials that you can order for free from: www.greenhouse.gov.au

Movies

- An Inconvenient Truth by Al Gore. A great study guide is available for the movie from: www.aninconvenienttruth.com.au/truth/guide.htm

Curriculum Links 7-10

NSW Grade 7-10 Science

Prescribed Focus Areas

Stage 4 Outcomes A student:	**Stage 5 Outcomes** A student:
4.1 identifies historical examples of how scientific knowledge has changed people's understanding of the world	5.1 explains how social factors influence the development and acceptance of scientific ideas
4.2 uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena	5.2 describes the processes that are applied to test and validate models, theories and laws
4.3 identifies areas of everyday life that have been affected by scientific developments	5.3 evaluates the impact of applications of science on society and the environment
4.4 identifies choices made by people with regard to scientific developments	5.4 discusses evidence supporting different viewpoints
4.5 describes areas of current scientific research	5.5 analyses how current research might affect people's lives

Domain: Knowledge and Understanding

Stage 4 Outcomes A student:	**Stage 5 Outcomes** A student:
4.6 identifies and describes energy changes and the action of forces in common situations	5.9 relates the development of the universe and the dynamic structure of Earth to models, theories and laws and the influence of time
4.7 describes observed properties of substances using scientific models and theories	5.10 assesses human impacts on the interaction of biotic and abiotic features of the environment
4.8 describes features of living things	5.11 analyses the impact of human resource use on the biosphere to evaluate methods of conserving, protecting and maintaining Earth's resources
4.9 describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe	
4.10 identifies factors affecting survival of organisms in an ecosystem	
4.11 identifies where resources are found, and describes ways in which they are used by humans	

Domain: Skills

Stage 4 Outcomes A student:		Stage 5 Outcomes A student:	
	follows a sequence of instructions to undertake a first-hand investigation	5.14	undertakes first-hand investigations independently with safety and competence
4.14	accesses information from identified secondary sources	5.15	gathers first-hand data accurately
4.16	evaluates the relevance of data and information	5.16	accesses information from a wide variety of secondary sources
4.17	with guidance, presents information to an audience to achieve a particular purpose	5.17	explains trends, patterns and relationships in data and/or information from a variety of sources
4.18	draws conclusions based on information available	5.18	selects and uses appropriate forms of communication to present information to an audience
4.19	uses an identified strategy to solve problems	5.19	uses critical thinking skills in evaluating information and drawing conclusions
4.20	uses creativity and imagination to suggest plausible solutions to familiar problems	5.20	selects and uses appropriate strategies to solve problems
4.21		5.21	uses creativity and imagination in the analysis of problems and the development of possible solutions

Domain: Values and Attitudes

Stage 4 and/or 5 Outcomes A student:	
4/5.24	respects differing viewpoints on science issues and is honest, fair and ethical
4/5.25	recognises the relevance and importance of lifelong learning and acknowledges the continued impact of science in many aspects of everyday life
4/5.26	recognises the role of science in providing information about issues being considered and in increasing understanding of the world around them
4/5.27	acknowledges their responsibility to conserve, protect and maintain the environment for the future

NSW Grade 7-10 Geography

Objectives Students will develop:	**Stage 4 Outcomes** A student:	**Stage 5 Outcomes** A student:
skills in acquiring, processing and communicating geographical information	4.1 identifies and gathers geographical information 4.2 organises and interprets geographical information 4.3 uses a range of written, oral and graphic forms to communicate geographical information	5.1 identifies, gathers and evaluates geographical information 5.2 analyses, organises and synthesises geographical information 5.3 selects and uses appropriate written, oral and graphic forms to communicate geographical information
skills in choosing and applying appropriate geographical tools	4.4 uses a range of geographical tools	5.4 selects and applies appropriate geographical tools
knowledge and understanding about the characteristics and spatial distribution of environments	4.5 demonstrates a sense of place about global environments	5.5 demonstrates a sense of place about Australian environments
knowledge and understanding about how people and communities modify, and are affected by, the environment	4.6 describes the geographical processes that form and transform environments 4.7 identifies and discusses geographical issues from a range of perspectives	5.6 explains the geographical processes that form and transform Australian environments 5.7 analyses the impacts of different perspectives on geographical issues at local, national and global scales
knowledge and understanding about how physical, social, cultural, economic and political factors shape communities, including the global community	4.8 describes the interrelationships between people and environments	

NSW Grade 7 to 10 Design and Technology

Objectives Students will develop:	**Stage 4 Outcomes** A student:	**Stage 5 Outcomes** A student:
1 knowledge and understanding of design concepts and processes	4.1.1 identifies and describes a range of design concepts and processes	5.1.1 analyses and applies a range of design concepts and processes
	4.1.2 describes and follows a process of design when developing design ideas and solutions	5.1.2 applies and justifies an appropriate process of design when developing design ideas and solutions
2 understanding and appreciation of the impact of past, current and emerging technologies on the individual, society and environments	4.2.1 describes the impact of past, current and emerging technologies on the individual, society and environments	5.2.1 evaluates and explains the impact of past, current and emerging technologies on the individual, society and environments
3 knowledge and understanding of the work of designers and the issues and trends that influence their work	4.3.1 describes the work and responsibilities of designers and the factors affecting their work	5.3.1 analyses the work and responsibilities of designers and the factors affecting their work
4 knowledge and understanding of and skills in innovation, creativity and enterprise	4.4.1 identifies innovative, enterprising and creative design ideas and solutions	5.4.1 develops and evaluates innovative, enterprising and creative design ideas and solutions
5 skills in communicating design ideas and solutions	4.5.1 communicates design ideas and solutions using a range of techniques	5.5.1 uses appropriate techniques when communicating design ideas and solutions to a range of audiences

NSW Grade 7 to 10 English

Objectives	Stage 4 Outcomes	Stage 5 Outcomes
Through responding to and composing a wide range of texts in context and through close study of texts, students will develop skills, knowledge and understanding in order to:	A student:	A student:
• speak, listen, read, write, view and represent	1 responds to and composes texts for understanding, interpretation, critical analysis and pleasure	1 responds to and composes increasingly sophisticated and sustained texts for understanding, interpretation, critical analysis and pleasure
	2 uses a range of processes for responding to and composing texts	2 uses and critically assesses a range of processes for responding and composing
	3 responds to and composes texts in different technologies	3 selects, uses, describes and explains how different technologies affect and shape meaning
• use language and communicate appropriately and effectively	4 uses and describes language forms and features, and structures of texts appropriate to different purposes, audiences and contexts	4 selects and uses language forms and features, and structures of texts according to different purposes, audiences and contexts, and describes and explains their effects on meaning
• express themselves and their relationships with others and the world	9 demonstrates understanding that texts express views of their broadening world and their relationships within it	9 demonstrates understanding of the ways texts reflect personal and public worlds
	10 identifies, considers and appreciates cultural expression in texts	10 questions, challenges and evaluates cultural assumptions in texts and their effects on meaning

NSW Grade 7 to 10 PDHPE

Strand 1: Self and relationships

Objectives Students will:	**Stage 4 outcomes** A student:	**Stage 5 outcomes** A student:
enhance their sense of self, improve their capacity to manage challenging circumstances	4.2 identifies and selects strategies that enhance their ability to cope and feel supported	5.2 evaluates their capacity to reflect on and respond positively to challenges
Strand 3: Individual and community health		
take actions to protect, promote and restore individual and community health	4.6 describes the nature of health and analyses how health issues may impact on young people	5.6 analyses attitudes, behaviours and consequences related to health issues affecting young people

Skills that enhance learning in PDHPE		
Objectives Students will:	**Stage 4 outcomes** A student:	**Stage 5 outcomes** A student:
develop and apply the skills that enable them to adopt and promote healthy and active lifestyles	**Communicating**	
	4.11 selects and uses communication skills and strategies clearly and coherently in a range of new and challenging situations	5.11 adapts and evaluates communication skills and strategies to justify opinions, ideas and feelings in increasingly complex situations
	Decision-making	
	4.12 assesses risk and social influences and reflects on personal experience to make informed decisions	5.12 adapts and applies decision-making processes and justifies their choices in increasingly demanding contexts
	Problem-solving	
	4.16 clarifies the source and nature of problems and draws on personal skills and support networks to resolve them	5.16 predicts potential problems and develops, justifies and evaluates solutions

Curriculum Links K-6

NSW Grades K to 6 Science and Technology

Knowledge and understanding – Content strands outcomes:

	Stage 1	Stage 2	Stage 3
Built environments Students will know and understand that:	- People alter their environments in response to natural conditions.	- People create specialized environments to meet specialized needs. - Environments are sometimes modified to fulfill new and different requirements.	- People try and control the conditions in the environments they build. - Both aesthetic and functional factors need to be considered when people make changes to their environments.
Living things Students will know and understand that:	- Living things grow, reproduce, move, need air, take in nutrients and eliminate wastes.	- Plants and animals live in environments that supply their needs. - Change occurs throughout the lifetime of the living things. - Living things depend on other living things to survive.	- The activities of people can change the balance of nature. - Groups of living things have changed over the long periods of time.
Earth and its surroundings Students will know and understand that:	- Time can be measured through change and regular events. - The weather can have a powerful effect on people.	- Most natural resources are limited and so need to be used wisely. - There are benefits and problems associated with human changes to their physical environment. - Most materials come from the Earth and its surrounds.	- There are many physical phenomena which change the environment. - There are various parts to the physical environment, e.g. stars, planets, earth, air and water.
Products and services Students will know and understand that:		- Manufacturing processes convert raw materials into useful products.	- There are environmental consequences of production and consumption.

Knowledge and understanding – Learning processes outcomes:

Students will develop their knowledge and understanding of the process of investigation that people use to develop reliable insights into the natural and made environments.	• state the purpose of an investigation. • demonstrate that tools and equipment can be used to aid observation.	• recognise that the results of investigations can lead to more questions. • show that designing and making can lead to the need for investigations. • give examples of predictions that are sometimes supported, sometimes disproved.	• describe the social, environmental or economic implications of the investigation of new materials and processes. • describe the process of investigation which can involve exploring and discovering phenomena and events, proposing explanations, initiating investigations, predicting outcomes, testing, modifying and applying understanding.
Students will develop their knowledge and understanding of the process of designing and making that people use in order to satisfy their wants and needs.			• justify the decisions made in designing and making. • describe the process of designing and making which can involve identifying needs and wants, defining a design task, generating and selecting ideas, assembling or constructing products, systems or environments, and evaluating outcomes.
Students will develop their knowledge and understanding of the technologies people select and use; how these technologies affect other people, the environment and the future.	• recognise that technological activity affects people and their environments.		• explain that the future must be considered when making choices of particular technologies. • evaluate technological activity in terms of social and environmental costs and benefits. • explain that particular technologies are significant causes of change in the way people live. • describe ways in which resources can be conserved.

Skills outcomes:

	Stage 1	Stage 2	Stage 3
Students will be able to investigate natural and made environments.	• undertake an investigation as a result of individual curiosity or as a means of solving problems. • interpret data and explain their observations.	• make accurate observations and describe these observations, or record them as diagrams, tables of data and graphs. • propose explanations using simple observations.	• make detailed observations using appropriate technologies. • discuss the factors that might affect an investigation.
Students will be able to design and make products, systems and environments to meet specific needs.	• combine a variety of materials and images to make simple models, drawings and structures. • describe to others the strengths and limitations of a design.		
Students will be able to select and use a range of technologies.	• choose classroom materials and tools appropriate to the activity. • recognise their own use of technology in the school and home environment.	• report on the social and environmental costs and benefits of familiar technology.	• use resources with consideration for the environment and adopt procedures which minimise waste. • record the economic, moral, social and environmental consequences of advances in technology.

Values and attitudes outcomes:

Values and attitudes towards science and technology		• Show informed commitment to improving the quality of the local environment. • be curious about and appreciate the natural and made environment.	• show informed commitment to improving the quality of society and the environment. • be curious about and appreciate the natural and made environment.

NSW Grades K to 6 HSIE

Overview of change and continuity outcomes

	Early stage 1	Stage 1	Stage 2	Stage 3
Time and change		CCS1.2 Identifies changes and continuities in their own life and in the local community.	Explains changes in the community and family life and evaluates the effects of these on different individuals, groups and environments.	

Overview of cultures outcomes

Cultural diversity	CUES1 Communicates some common characteristics that all people share, as well as some of the differences.		CUS2.4 Describes different viewpoints, ways of living, languages and belief systems in a variety of communities.	CUS3.4 Explains hoe cultures change through interactions with other cultures and the environment.

Overviews of environments outcomes

Patterns of place and location	ENES1 Gathers information about natural and built environments and communicates some of the ways in which they interact with, and can care for, these environments.	ENS1.5 Compares and contrast natural and built features in their local area and the ways in which people interact with these features.	ENS2.5 Describes places in the local area and other parts of the Australia and explains their significance.	ENS3.5 Demonstrates an understanding of the interconnectedness between Australia and global environments and how individuals and groups can act in an ecologically responsible manner.
Relationships with places	ENES1 also applies here	ENS1.6 Demonstrates an understanding of the relationship between environments and people.	ENS2.6 Describes people's interactions with environments and identifies responsible ways of interacting with environments.	ENS3.6 Explains how various beliefs and practices influence the ways in which people interact with, change and value their environment.

Overview of social systems and structures outcomes

Resource systems			SSS2.7 Describes how and why people and technologies interact to meet needs and explains the effects of these interactions on people and the environment.	SSS3.7 Describes how Australian people, systems and communities are globally interconnected and recognizes global responsibilities.